THURSDAY, DECEMBER 10, 1885

THE "ENCYCLOPÆDIA BRITANNICA"

Encyclopædia Britannica. Ninth Edition. Vols. XVIII. and XIX. (Edinburgh: A. and C. Black, 1885.)

THESE two volumes are almost entirely occupied with letter P, and yet it is not finished. Though there are no articles of the tremendous length of some in the earlier volumes, still there are many of more than the average length and importance. In Vol. XVIII. we have such articles as Ornithology, by Prof. Newton; Parallax, by Mr. David Gill; Pacific Ocean, by Mr. John Murray; and Phosphorescence, by Prof. Pritchard. In Vol. XIX. again we have a valuable fragment on the Physical Sciences, by the late Clerk Maxwell; Pisciculture, by Mr. Browne Goode; Planarians, by Prof. L. V. Graaf; Polar Regions, by Mr. C. R. Markham; Physiology, by Prof. M. Foster, Prof. McKendrick, and Mr. S. H. Vines; and Pianoforte, by Mr. A. J. Hipkins. We have only space to notice at length the articles on Ornithology, Physiology, and Pianoforte.

Prof. Alfred Newton's article "Ornithology" stamps him as the first ornithological critic of the day, and his treatment of this most difficult subject is, as far as it goes, a model of scientific arrangement and elegant diction. He traces the history of ornithology from the very earliest times by a record of successive authors and their work, and then discusses the families of birds with a dissertation on the merits of the various systems which have been lately proposed, but it is in the record of recent ornithological work that we find the most conspicuous failure of Prof. Newton to do justice to his contemporaries. Whether want of space compelled the author to abridge this part of the subject we know not, but if the article "Ornithology" is supposed to be a history of the science down to the year 1884, the student of the future will greatly wonder at the omissions, not knowing how to attribute them to a critic whose account of the early history of the subject is so wonderfully complete and minute. It was doubtless a mere oversight on the part of the author to have attributed the completion of Gould's "Supplement to the Humming-birds" to Mr. Salvin instead of to Mr. Sharpe, but we should have expected to find some little account of the publications of the last-named ornithologist, whose name is not mentioned in connection with the "Catalogue of Birds in the British Museum," with which it is likely to be remembered in the history of ornithology, more than with the foundation of Dresser's "Birds of Europe," and with the second edition of Layard's "Birds of South Africa," with which Prof. Newton associates it. In the latter case Mr. Sharpe must be held to have done his work badly, as, despite his incorporation of all the excellent work of Mr. J. H. Gurney in his edition of "Layard," the latter ornithologist has a "knowledge of South African ornithology perhaps greater than that of any one else." No classification of birds as yet proposed satisfies Prof. Newton, any more than it does any other ornithologist; but Mr. Sharpe's publication of Sundevall's scheme of classification will *not* be considered "so much waste of time" by those who recognise that, with all its faults, it contains, like all well-matured schemes, many points of excellence and hints on classification in advance of his predecessors. The same must be said of Dr. Sclater's recent scheme, and also of Prof. Newton's own critical remarks in the present article. All are contributions towards a final natural arrangement of the class "*Aves*," if such indeed will ever be compassed. The arrangement of the British Museum "Catalogue" is well known to be faulty, but it is only by the complete description of every genus and its component species that a correct idea of their relations can ultimately be entertained, and to entirely ignore the new volumes of the "Catalogue" is at least matter for wonderment, seeing that already 4116 species have been described in its pages with their full synonymy up to date, while 196 species have been figured. Similarly Prof. Newton, in his enumeration of recent works on British ornithology, omits to mention Mr. Seebohm's name altogether, though the "History of British Birds" was far advanced towards completion in 1884. We might also complain of the scant justice done to Mr. Harting, whose popular work on the "Birds of Middlesex" was the forerunner, if not the exact model, of many of those books on county ornithology, space to mention which is found by Prof. Newton. No doubt some future historian will carry on the record of ornithological prowess from the point where it is left by Prof. Newton, but one thing is certain, that every subsequent writer will be indebted to the author for his facts concerning the early history of ornithology, which we believe to be one of the most complete and exhaustive records ever published.

The article "Physiology" in the last-issued volume is a threefold one of considerable length. Dr. Vines gives us an extended treatise on vegetable physiology, whilst Prof. McKendrick discusses in detail certain aspects of the physiology of the nervous system. Without detracting from the merit of these two pieces of work, which are full of valuable information, we may say at once that the section of the article written by Prof. Michael Foster, which precedes these, is that which will command most attention and indeed should be read by every student of science as well as by the intelligent layman who wishes to know the past, present, and future of the branch of science which is, perhaps more than any other, destined to influence the welfare of humanity. Prof. Foster's essay is in fact a very remarkable one; admirable in style, vigorous and lucid, it gives the reader the impression, which is well founded, that he is being shown the inner history of the growth and development of a great science by one who has the clear vision and unerring judgment of a master of his subject. Hereafter Prof. Foster's article will retain permanent value as the best exposition of the way in which the problems of physiology were regarded, both retrospectively and with a view to future progress, in the latter quarter of the nineteenth century.

Prof. Foster commences by defining physiology as "the study of the actions of living beings on their surroundings and correlatively of the action of the surroundings on the living being," whilst he points out that at an earlier period physiology comprised morphology and corresponded to what is now called biology.

Then follows a sketch of these "actions of a living being." They are brought under three heads:—(1)

Movements: dependent upon the contractions of muscles and the existence of mechanical contrivances connected therewith. (2) *Activity of the Nervous System*; in controlling in various ways and in relation to various external and internal conditions the before-named movements. (3) *Chemical Changes*; these are briefly sketched as not only those directly concerned in the contraction of muscle, but as occurring in all parts of the body. They may be regarded as a slow combustion in which complex substances full of latent energy are reduced to simpler stable conditions with less or with no latent energy. Like St. Paul, the animal, says Dr. Foster, "dies daily." "All the inner labour of the body, both that of the chemical gland-cells, of the vibrating nerve-substance with its accompanying changes of consciousness, and of the beating heart and writhing visceral muscles, is, sooner or later, by friction or otherwise, converted into heat; and it is as heat that the energy evolved in this labour leaves the body." Only as heat or as motion of limbs, jaws, &c., does the energy set free in the animal body make itself externally apparent. This combustion and degradation of material necessitates new supplies, and hence we have the phenomenon of the inception of food and the chemical processes connected with it.

The Problems of Physiology are then stated as the result of the preceding survey of the actions of a living being to be as follows:—(1) To discover the laws of transmutation of complex unstable food into still more complex living flesh, and the laws by which the latter breaks down into waste products, void of energy. (2) To discover the laws of the origin of nervous vibrations, of their passage to and fro in nerve substance and of their ultimate disappearance in connection with muscular contraction or otherwise. (3) To discover the laws of how the energy of chemical action is transmuted into and serves as the supply of that vital energy which appears as movement, feeling, and thought.

This rough analysis of the problems of physiology is "the residue of many successive phases of opinion." It is in tracing the influence of these successive phases and estimating the value of their residues that the skill of Prof. Foster is most successfully exerted. Such an appreciation of the historical significance of the various factors of his science, should, we think, be as much the indispensable possession of a cultivated specialist as is a knowledge of his country's political history to the statesman.

The exigencies of life, Dr. Foster tells us, early directed man's attention to the phenomena of the animal body and thus brought the study of physiology to the front before its time. Hence in the absence of the knowledge of physics and chemistry, explanations were assigned to those phenomena of animal bodies which were not obviously identical with those of inanimate bodies, under the names "vital spirits" and "animal spirits." In the seventeenth and eighteenth century, however, the progress of anatomical knowledge led to the perception of the fact that the animal body contained, if it did not actually consist of, a number of mechanical contrivances each of which could be shown to perform some service in the animal economy for which its construction especially fitted it. In this way grew up the doctrine of "organs" and "functions," and it was held that the inspection of structure was sufficient to enable an acute observer to determine the particular function of any given part. Great progress was made under the influence of this doctrine—the most notable example of its triumph being the discovery by Harvey of the function of the heart and the mechanism of the circulation of the blood. The doctrine of vital and animal spirits still survived as giving an explanation of the motive force which set the complicated machinery of connected organs at work.

In the physiological "cell-theory" of Schleiden and Schwann the adequacy of the doctrine of organs and functions to explain the phenomena of life, whilst apparently finally established, received, according to Dr. Foster, its death-blow. It appears to us that Dr. Foster does not quite give its true significance to "the cell-theory." It is true that the founders of that theory attached undue importance to the structural characters of the cell. But Schwann at any rate attached the greatest importance to the cell-substance, and to its molecular and atomic constitution, and the doctrine that function is dependent on structure, when by structure we understand not merely coarse visible structure, but molecular structure, which differs in any two cases by a difference of internal movement of molecules rather than by a difference of their permanent position—this doctrine is triumphant to-day, and is proclaimed in that portion of the present article which treats of different kinds of protoplasm.

A quotation is given from a well-known article by Prof. Huxley, written thirty years ago, in which it is stated that cells "are no more the producers of the vital phenomena than the shells scattered in orderly lines along the sea-beach are the instruments by which the gravitative force of the moon acts upon the ocean." Apparently Dr. Foster thinks this statement to be defensible even to-day, but the conception of living matter and of the significance of cell-substance and structure thus indicated appears to us to be more difficult to reconcile with the modern doctrine of protoplasm than is the doctrine of Schwann, which, to use his own words, was "le contraire de la théorie generalement admise pour les animaux, d'après laquelle une force commune construit l'animal à la manière d'un architecte," and which argued from the uniform construction of organisms by modification of the nucleated corpuscles called cells that "c'est partout la même force qui reunit les molécules en cellules, et cette force ce ne pouvait plus être que celle des molécules ou des atomes; le phénomène fondamental de la vie devait donc avoir sa raison d'être dans les propriétés des atomes"—that is to say, in the atoms of the substance of which the cells consist which has now received the name protoplasm.

Dr. Foster next gives a vivid picture of the importance of the discovery by Claud Bernard of the glycogenic function of the liver—a function which could not be inferred from the inspection of the liver either macroscopic or microscopic. Such discoveries as these led to the recognition of the existence of most important processes or "functions" in the animal body which had no correlative in visible structure. Thus physiologists were led to see in the mind's eye the invisible structure of cell-substance and the "protoplasm theory" obtained its foundations.

A brief survey of the life of a corpuscle of protoplasm as exemplified in an Amœba follows, and attention is directed to the *constructive* and *destructive metabolism* going on in the substance of such an organism. There are anabolic and katabolic changes in that substance, which may be compared to a double flight of stairs leading up to and down from a hypothetical summit; that summit is what we mean by protoplasm, but whether the term should include a few of the steps up or down or be limited to the top plane cannot at present be decided.

This protoplasm of the unicellular organism exhibits properties which may be classed as (1) *Assimilation;* (2) *Contractility;* (3) *Irritability* or *Sensitiveness.* From the consideration of these we are led on to that of a simple multicellular organism—a Hydra—in which a first stage of differentiation of these properties between two groups of cells—the endoderm and the ectoderm—is observed. Then in due course the further differentiation of these two primary groups of cells in a higher animal is traced —in an account of the organs and tissues with their specialised properties and functions derived by gradual modification from the lower stage of differentiation.

The relation of the complex organs, composed of numberless cell-units, of a higher organism to the practically homogeneous protoplasm of a single cell-corpuscle having thus been traced, Dr. Foster takes one organ of a higher animal—the kidney—as an example of the problems which present themselves to the modern physiologist. There are, he points out, two points of view, two aims of inquiry which pursue in many respects different methods, though ultimately blending and tending conjointly to the explanation of the action of the kidney. They are distinguished as the "mechanical" and the "molecular," and correspond in these later days to the earlier and later standpoints of physiology represented by the doctrine of organs and the doctrine of cell-substance. The physiologist's inquiry is sketched from the first point of view, and it is pointed out that this inquiry "takes on to a large extent the characters of an attempt to unravel an intricate game, in which the counters are nervous impulses, muscular contractions, and elastic reactions, but in which the moves are determined by topographical disturbances and mechanical arrangement." The second kind of physiological inquiry into the kidney ignores for the time being these grosser conditions, and is directed to the molecular action of the protoplasmic cells which build up the distinctive structure of the kidney, namely, its tubules.

Reverting to "a brief survey of the whole field of physiological inquiry," Dr. Foster says:—"The master tissues and organs of the body are the nervous and muscular systems, the latter being, however, merely the instrument to give expression and effect to the motions of the former. All the rest of the body serves simply either in the way of mechanical aids and protection to the several parts of the muscular and nervous systems, or as a complicated machinery to supply these systems with food and oxygen, *i.e.* with blood; and to keep them cleansed from waste matters through all their varied changes."

That, no doubt, is true if the organism be viewed as an individual and not from the point of view which regards the individual as one of a race and the race as part of the general outcome of organic development, and this as again a part of a more general phenomenon. The biologist who takes his stand on the doctrine of evolution must, we venture to think, regard as the "master-tissue" over and above those indicated by Dr. Foster—the reproductive tissue or the specific cells of the ovary and testis. It is in every animal this little nest of germ-plasma handed on from generation to generation with scarcely a change which receives the homage and service of all the various products of differentiation of its brother-cells. The latter are but the carriers, protectors, and servants in the struggle for existence of the undifferentiated germ-plasma—even the cells concerned in thought and reason exist but to protect the germ-cells. The former perish as a mere husk whilst the germ-plasma is immortal; it forms, by growth and fission, on the one hand, new germ-plasma which never dies, and on the other hand protecting tissue-cells, which have only an evanescent existence. As Dr. Foster himself has elsewhere said:—"The animal body is in reality a vehicle for ova, and after the life of the parent has become potentially renewed in the offspring the body remains as a cast-off envelope whose future is but to die."

In the latter part of the article our present knowledge of the nature of protoplasm, and of the processes which go on in connection with it, is forcibly sketched. Different *kinds* of protoplasm are recognised, the differing qualities of which are to be regarded by the biologist as "the expression of internal movements" of the molecules of the protoplasm. The term "mesostate" being used to express those ascending and descending steps of the pyramid whose summit is protoplasm, and "anastate" and "katastate" corresponding respectively with those constituents of cell-substance which are on their way to attain, and those which are falling away from the state of perfect protoplasm, we find that the tendency of inquiries into the molecular processes taking place in living secreting cells, in muscular tissue, and in the various forms of nerve-tissue, "is to lead us to regard the varied activities of these tissues as due to molecular disruptive changes in their several katastates, these being various stages of the downward metabolism or katabolism of protoplasm."

Hering's recent speculations on the relation of colour sensations to the condition of the protoplasm of the percipient cells lead, Dr. Foster thinks, to a new molecular physiology. He gives us the hope that by an application of Hering's conceptions (which the limits of our space do not permit us to notice more fully) to other groups of protoplasmic units a new departure may be effected, and that we may look forward to a very great advance in our knowledge of the nature of the processes taking place in living cells.

Dr. Foster concludes his article with an outline of the methods of physiological inquiry and an unanswerable though brief exposition of the dependence of the progress of physiology upon experiment on living organisms.

The article on Pianoforte is of considerable interest for several reasons; first, because it is signed with the initials of Mr. A. J. Hipkins; secondly, from the number and felicity of the illustrations; thirdly, because it takes up a special and somewhat neglected point in the history and development of the remarkable instrument which has superseded the far more ancient organ, and which has become the domestic companion and indispensable accessory in thousands upon thousands of households throughout the civilised world.

Probably no man living knows so much about the pianoforte as Mr. Hipkins: attached for many years to the honoured house of Broadwood and Sons; almost able to remember its original title of Tschudi and Broadwood, which carries us back at one bound to the epoch of the harpsichord Mr. Hipkins is not only an experienced musician, but an excellent physicist in his special line. He has read valuable papers before the Royal Society, and efficiently co-operated with Mr. Alex. Ellis in his laborious determinations of pitch and of oriental or archaic musical scales.

The somewhat neglected subject here given with the terseness and accuracy of a monograph, as is proper in a work somewhat of the nature of an index, is the mechanical development of the modern pianoforte from the earliest form of keyed instrument with strings, shown in a drawing by Miss Edith Lloyd of a sculpture in St. Mary's Church, Shrewsbury belonging to the first half of the fifteenth century. Besides this and other woodcuts of typical instruments, is a series of diagrams showing the various forms of "tangent," "jack," "hammer," "action," and "escapement" by which the sounding string has been successively made to vibrate with ever increasing fulness and beauty of tone and quality. Towards the end of the article the recent substitution of metal for wooden framings is similarly summarised and illustrated. No doubt much of this would be hard reading for an unmechanical student; but it was really needed, and as a compact whole could hardly be said to exist previously.

The early part of the article appeals to every reader, and is full of fascinating and original research. There are eleven other capital woodcuts besides that named above of clavichords, clavicymbalums, spinetts, and clavicytheriums, which, under a multiplicity of names, preceded the four "gravicembali col piano è forte," which Cristofori, the Paduan harpsichord maker had, on the undoubted authority of the Marchese Scipione Maffei, completed in the year 1709. This date may be looked on as the birthday of the name and the instrument. Originally adjectival and explanatory, it has been adopted substantively wherever this ubiquitous form of the "dulcimer with keys," as Mr. Hipkins quaintly defines it, has penetrated.

BALL'S "STORY OF THE HEAVENS"

The Story of the Heavens. By Robert Stawell Ball, LL.D., F.R.S., Royal Astronomer of Ireland. (London, Paris, New York, and Melbourne: Cassell and Co., Limited, 1885.)

POPULAR works on astronomy, either on its entire range or selected portions, have been so numerous of recent years as to make it difficult to judge a new one entirely on its own merits; it is felt that there must be some well-marked originality of plan or execution, some novelty of treatment, or freshness of fact, to justify an addition to an already abundant literature.

The present work can urge its claim to a favourable reception on a twofold ground; it is the fullest and most complete exposition of the leading facts and principles of astronomy which has yet been laid before the entirely unscientific public, and it devotes special attention to some of the most recent and interesting astronomical discoveries. It is in no sense whatsoever a student's book, but aims to give, in such simple and untechnical language as may be most acceptable to the general reader, a comprehensive view of the results of astronomy as at present received. So thoroughly is it elementary in character that Dr. Ball from time to time seems to think he has a childish audience before him, and descends to a style which is nowadays considered almost too condescending to be addressed even to children. Thus, in speaking of the distance of the sun, he says (p. 28):—

> "The actual distance of the sun from the earth is about 92,700,000 miles; but merely reciting the figures does not give a vivid impression of the real magnitude. 92,700,000 is a very large quantity (*sic*). Try to count it. It would be necessary to count as quickly as possible for three days and three nights before one million was completed; yet this would have to be repeated nearly ninety-three times before we had even counted all the miles between the earth and the sun."

But though Dr. Ball may sometimes resort to this infant-school style he never falls into the opposite fault of being turgid or obscure. His language is always clear and distinct, and when treating of the particular subjects most congenial to him he usually succeeds in avoiding the fault we have just noticed, and his style leaves nothing to be desired.

In a brief introduction Dr. Ball indicates the principal questions which it is the business of the astronomer to seek to answer, and glances at some of the most important discoveries made by the ancients, concluding with the labours of Copernicus. The main volume then commences with a chapter on the astronomical telescope. The Dunsink South equatorial, the great Vienna refractor, and Lord Rosse's 6-foot reflector are described, and illustrations given of them; the Paris meridian circle is represented as a type of meridian instruments, and a well-written page (p. 22) is devoted to drawing a contrast between the ideal instrument and the actual one.

A number of chapters on the different members of the solar system follow. These occupy more than half the volume, and do not call for much special comment, for, whilst travelling over such well-trodden ground, there is but little scope for original treatment. The author throughout gives a clear matter-of-fact account of what he has to describe; there is never for a moment any difficulty in following his meaning, and for a work of this character this is a first essential. The chapter on the Sun is perhaps the least successful. Dr. Ball considers that it is not proved that "sun-spots are really depressions in the surface"; a statement which may be perfectly correct if "proved" is to be taken in its hard mathematical sense; but it ought to be supplemented by the further one that the entire evidence is in favour of that supposition. No reference is made to the frequently-repeated coincidences of solar outbursts and magnetic disturbances which were observed in 1882 and 1883, and which placed the connection of the two orders of phenomena in such a striking light. And again with reference to the spot-cycle, the nature of the cycle is rather crudely stated, and one of its most curious